

Curious numerical coincidence to the Pioneer anomaly

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ABSTRACT

One noticed a pure numerical coincidence between the Pioneer spacecrafts deceleration anomaly and $(\gamma - 1)$, with γ the Lorentz factor. The match is not only for distances larger than 20 AU, but even for the observed slope between 10 and 20 AU.

Keywords: Pioneer anomaly, Lorentz factor, numerical coincidence, space.

1. INTRODUCTION

The Pioneer spacecrafts unmodeled deceleration (towards the Sun) of $a_P = (8.74 \pm 1.33) \cdot 10^{-10} m/s^2$, for heliocentric distances greater than 20 AU, was reported in 1998¹ and 2002,² based on an initial dataset. This anomaly was confirmed³ recently using newly recovered and carefully verified data. The deceleration, observed for both Pioneer spacecrafts, was confirmed as well by independent investigations.⁴⁻⁷ Therefore, approximation algorithms or errors in the navigation code have been ruled out as possible causes of the anomaly. Alternatively, several physical mechanisms came up and claimed being able to justify the target value of a_P , by using standard or new physics theories.⁸ For the time being, none seems to convince the scientific community.

Another way to handle this issue is by reverse engineering, i.e. finding an expression which gives a numerical coincidence to the anomaly and only then one builds a model behind. One such example is the fact that $\sqrt{G \cdot m_P / a_P}$ has the same order of magnitude as the Compton wavelength of a proton, with G the gravitational constant and m_P the proton mass.⁹ Similarly, several authors explained why $a_P \simeq c \cdot H_0$ could make sense,¹⁰ with H_0 the Hubble constant and c the speed of light in vacuum.

Most of those models focus on a constant value, while it's not certain that the anomaly is constant. Actually, the initial dataset suggests² that the anomaly has very different values at distances less than 20 AU, while having a small gradient towards the larger distances. In addition, differences between the anomaly of Pioneer 10 and 11 could be expected. The analysis of the newly recovered data may, hopefully, clarify those aspects.

2. NUMERICAL COINCIDENCE

One proposes here a reverse engineering challenge starting with the numerical coincidence that:

$$a_P \simeq \gamma - 1, \quad (1)$$

where $\gamma = 1/\sqrt{1 - \beta^2}$ is the Lorentz factor, $\beta = v/c$, and v is the radial spacecraft velocity with respect to the Sun (~ 12 Km/s at more than 20 AU). At a first look, it could make sense as a residual value, as a_P , could be explained by an excess factor, as $(\gamma - 1)$ coming from the Special Theory of Relativity. However, $(\gamma - 1)$ is an unitless factor, usually multiplicative, and there is no physical reason to compare it with an acceleration. On the other hand, it's still interesting to see how well it matches the observational values of a_P and, eventually, it could point to non-physical explanations of the anomaly.

Firstly, for $v = 12$ Km/s, $(\gamma - 1) = 8.0 \cdot 10^{-10}$, which is very well in the range of the observed a_P values. Secondly, $(\gamma - 1)$ varies as a fonction of v , which changes with the heliocentric distance, and produces a very close match to the observed a_P (figure 1). The trajectory data used here comes from the JPL HORIZONS on-line solar system data and ephemeris computation service.¹¹ The time stamps corresponding to positions are ranging

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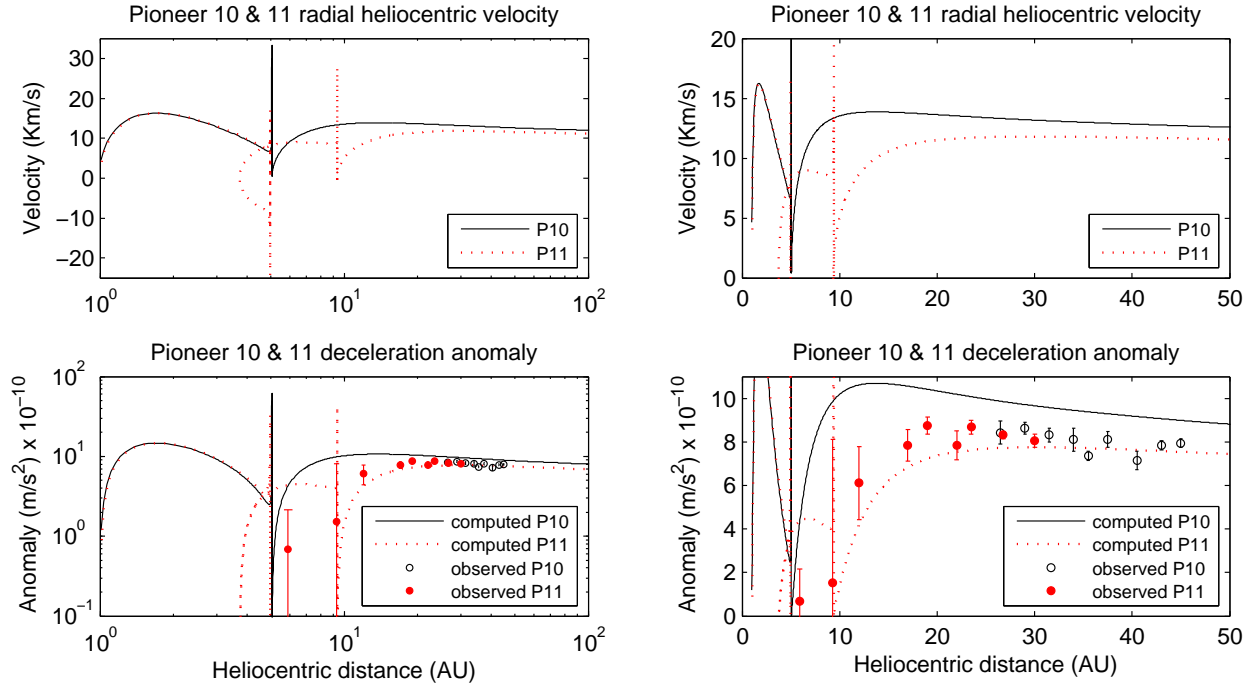


Figure 1. Spacecrafts radial heliocentric velocity (upper graphs) and the corresponding computed anomaly using $(\gamma - 1)$ (lower graphs). The left side graphs have logarithmic scales on the horizontal axis, while on the right it's a zoom having linear scales. Comparatively, the observed values of the anomaly² with errorbars are presented. P10 and P11 stand for Pioneer 10 and 11, respectively.

from few minutes to 7 hours, in order to provide smooth trajectories, especially during Jupiter and Saturn flybys, at 5 and 9.4 AU, respectively.

Analyzing the figure 1, one can observe that the expression (1) provides, for both spacecrafts, good approximations to the observed a_P values. Sometimes, $(\gamma - 1)$ is outside the errorbars, but the initial Pioneer dataset also contained some bad values and therefore the errorbars may not be very accurate. A lack of accuracy is suggested as well by the fact that the observed values don't follow a very smooth trend, as it should if they follow a certain model. One needs to emphasize that the strong anomaly slop, between 10 and 20 AU, suggested by the Pioneer 11 observations, is pointed out by $(\gamma - 1)$ behavior too. Moreover, as the observed anomaly errorbars represent the standard deviation over 10 days, this suggests important variation of the anomaly at the Pioneer 11 Saturn flyby (9.4 AU). The values given by $(\gamma - 1)$ show such a behavior too.

3. CONCLUSIONS

The Pioneer spacecrafts deceleration anomaly is computed from the observed trajectory, which computation could be affected by a relativistic term as $(\gamma - 1)$. Therefore it makes sense to investigate if this match with an unitless factor is a code error, any other non-physical effect, or just a simple curiosity. The anomaly computed from the newly recovered Pioneer data could, hopefully, bring more precision.

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